FLYTENDE HAVVIND FOR Å DEKARBONISERE NORSK SOKKEL: HVA SKAL TIL?

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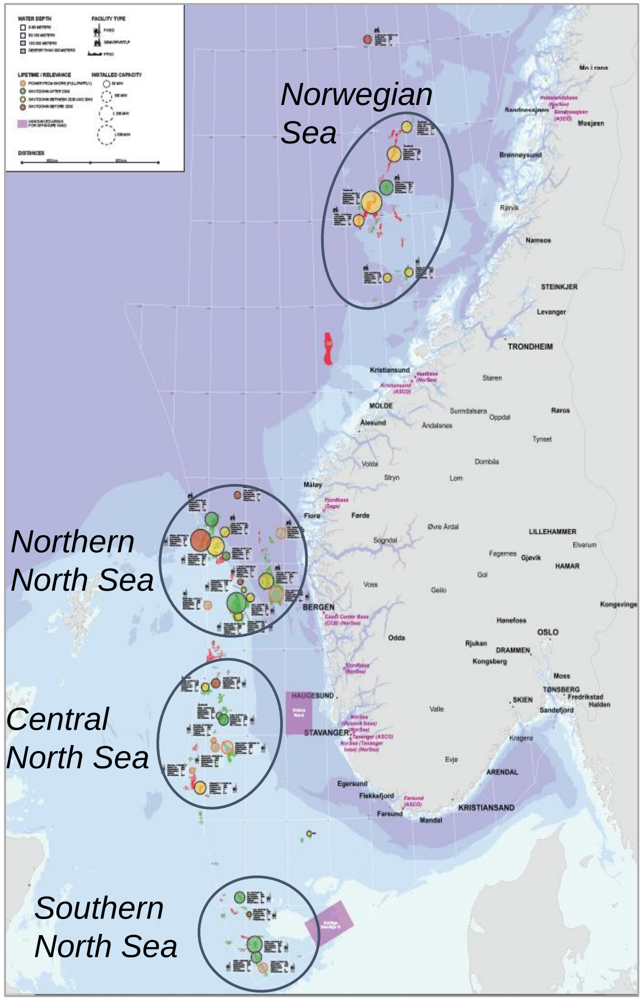
OSLO, 10.03.2020

Offshore platforms are attractive off-takers for first large scale floating wind farm(s) in Norway



- Offshore oil and gas producers more attractive off-takers of electricity from first large scale floating wind farm(s), than power to grid

- Northern North Sea most suitable for combining offshore facilities with large scale floating wind (~500MW). Low cost capital combined with investment friendly fiscal regime can turn the case commercial

- Further costs reductions could trigger 1-3 additional large scale floating wind farms (~500 MW) towards oil and gas facilities within 2030, as part of the ambition to realize floating wind in Norway

- Realize floating wind in Norway sooner rather than later:
    - Likely industrialized within 2030
    - Expand toolbox to meet climate targets
    - Oil & gas fields with limited remaining life

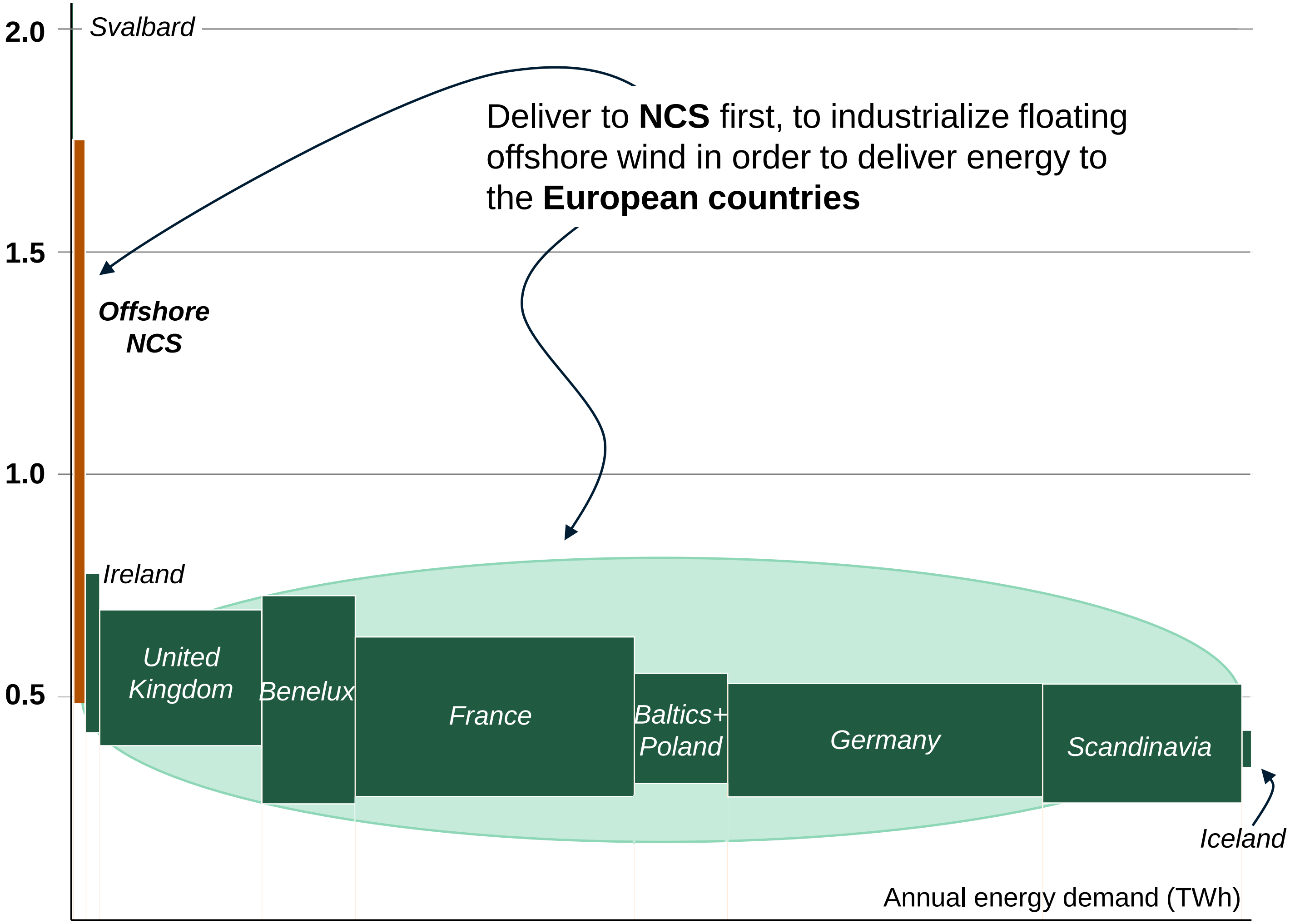
Backdrop for report

Wind will continue to blow, but the industrialization of floating wind is starting now	• *Floating offshore wind to supplement other renewables* • *Technology in place, industrialization and scale to reduce costs* • *Governments and industry to position themselves for market shares*
Floating offshore wind - “a three in one” for Norway	• *Develop new jobs and industry, with large export potential* • *Reduce CO_2 emissions in Norway and abroad* • *Realize offshore wind resources in Norway*
Call for multiple large-scale floating wind farms in Norway	• *Industry calling for large-scale floating wind projects to reduce costs* • *Need for large-scale projects in Norway to develop a home market*

Source: Rystad Energy research and analysis

Why look offshore NCS? High energy costs - large energy consumers – need to cut CO2

2018 energy cost and demand for the NCS and relevant countries for future export
NOK/kWh (spread based on monthly min and max for onshore grid & field distribution on the NCS)



- E&P with ambitions to reduce CO2 emission by 40% within 2030 and 70% by 2040
- Floating offshore wind can reduce CO2 emission through the development of dedicated clean energy supply
- **Is Hywind Tampen a one-off or could we expand into large scale?**

*The energy cost for each country reflects the span in monthly spot prices (excl. grid costs and taxes) during 2018/2019
Source: Nordpool, European Commission, Thomson Reuters, Landsnet.is, Interviews, Rystad Energy research and analysis

10 reasons to develop floating offshore wind in Norway

Realize offshore wind resources	Reduce CO_2 emissions	Develop new jobs and industry

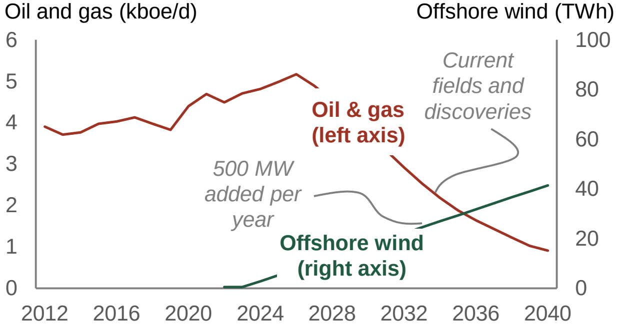
1 Offshore wind is highly competitive
Bottom fixed offshore wind is a highly competitive energy source compared to other energy sources; cost trajectories of floating and bottom-fixed wind are expected to converge during the 2020s.

2 Excellent offshore wind resources
Norway has excellent wind resources offshore, better than onshore and most other offshore regions. However, floating solutions are required, as water depths mostly exceed 60 meters.

3 Electrification requires more power
Domestic demand for more green power to realize stated climate ambitions. Replacing fossil fuels in Norway implies 30-50 TWh in additional domestic demand annually.

4 Maintain position as energy exporter
Offshore wind could enable substantial energy exports from Norway, also after the age of oil and gas. Export method is flexible, either as electrons, green molecules or energy intensive products.

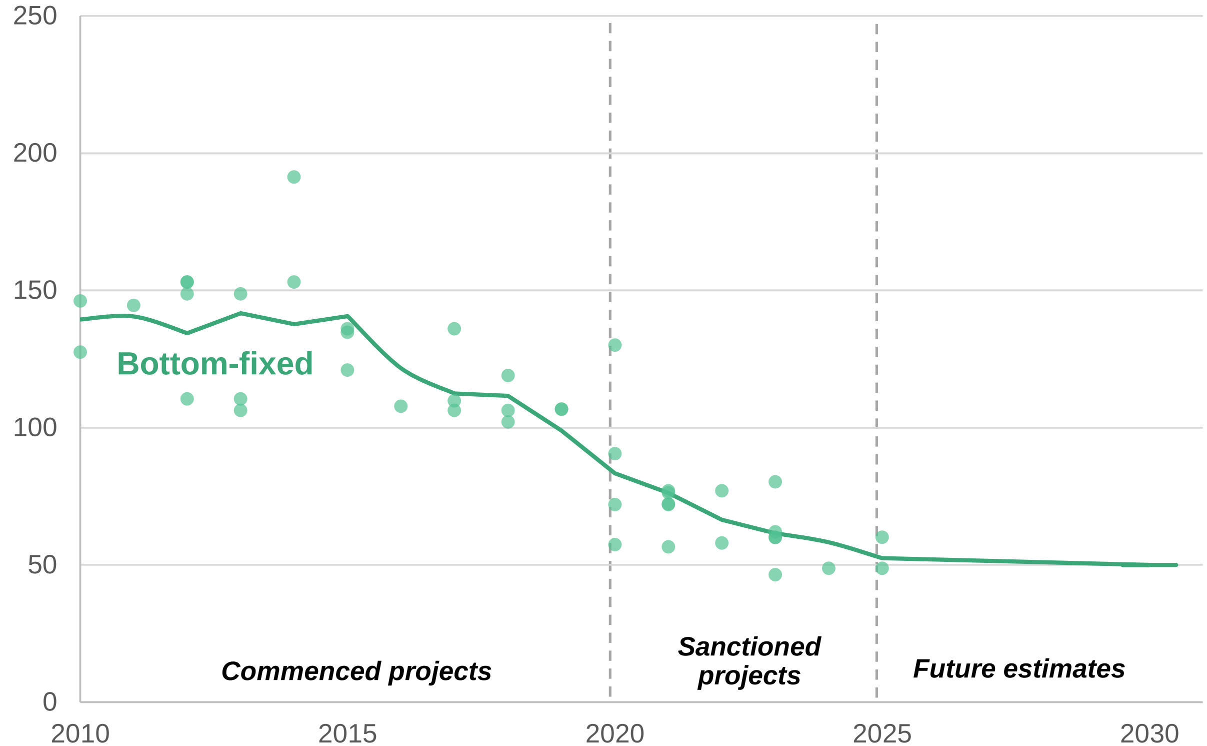
Offshore energy production



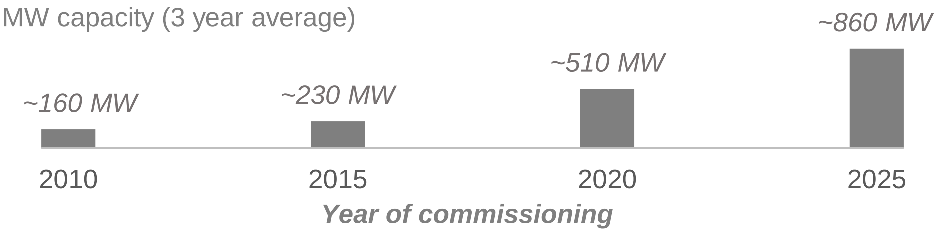
Source: UCube; Statnett – Et elektrisk Norge (April 2019); Menon (Sept 2019); Norsk olje og gass (Jan 2020); Rystad Energy research and analysis

1 Bottom fixed offshore wind reduced cost by ~2/3 over a short period of time

Cost development of European offshore wind farms* from 2010 to 2030
Levelized cost of energy (LCOE) by start-up year (EUR/MWh)



Wind farm size development for European bottom-fixed*
MW capacity (3 year average)

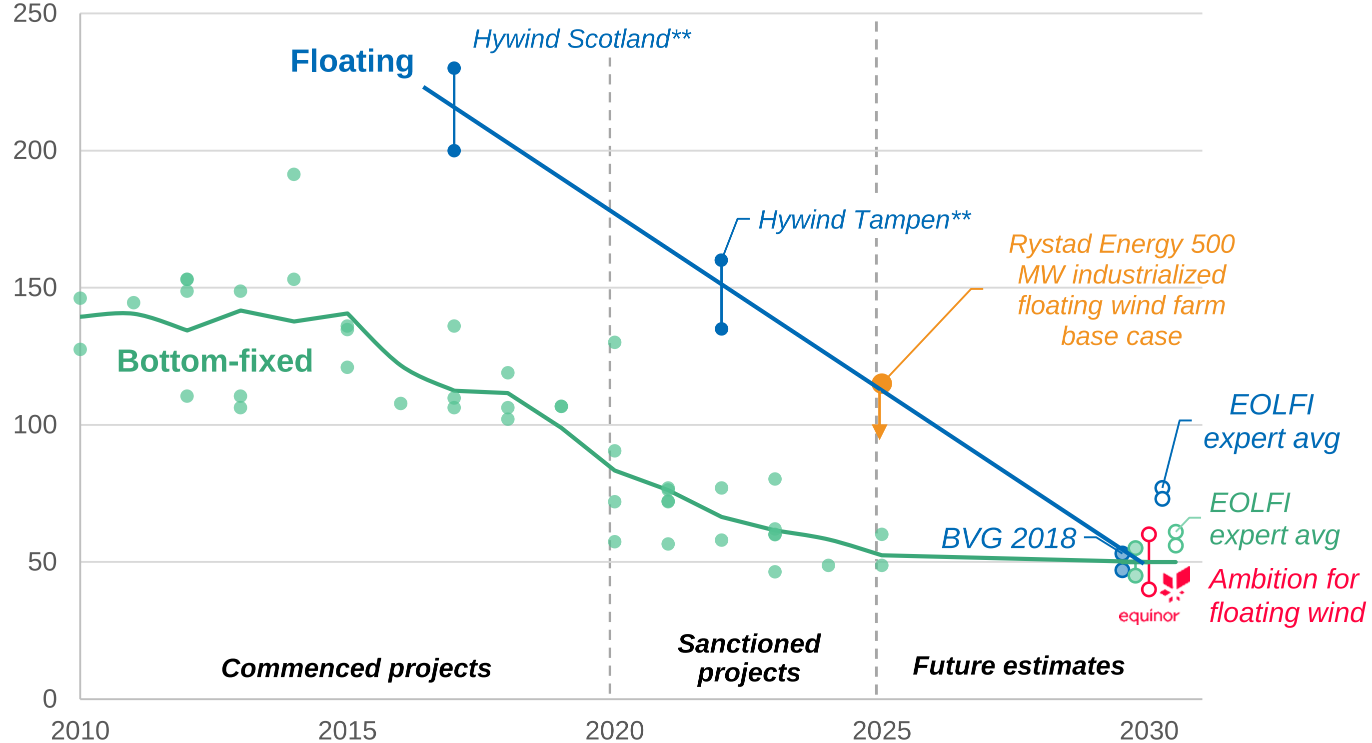


- Three main elements behind this development:
  - Larger park sizes
  - Larger turbines
  - Competitive auctions (introduced from 2015)

*Selected projects only. Data points from stated LCOE with transmission, strike prices or calculated based on investment cost with a WACC of 8%. Includes transmission to shore. **Various estimates
Source: IEA 2019, IRENA 2018, Equinor, BVG Associates 2018, EOLFI 2018, Catapult, Carbonbrief, Rystad Energy research and analysis

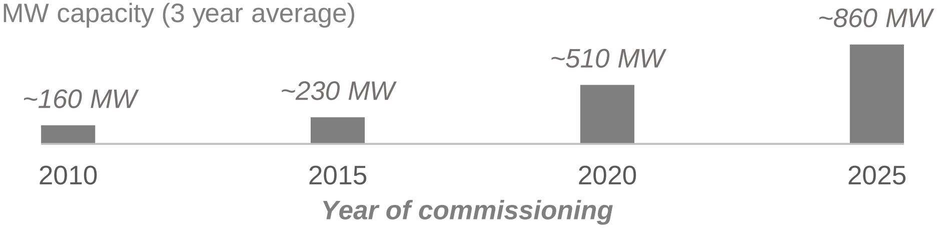
1 Cost of floating offshore wind to converge towards bottom fixed with industrialized approach

Cost development of European offshore wind farms* from 2010 to 2030
Levelized cost of energy (LCOE) by start-up year (EUR/MWh)



- Three main elements behind this development:
  - Larger park sizes
  - Larger turbines
  - Competitive auctions (introduced from 2015)
- Industry estimates for floating wind of 40-70 EUR/MWh in 2030.
- Industry cost estimates that Rystad Energy has gathered put a first large floating wind farm(~500 MW) at ~115 EUR/MWh.

Wind farm size development for European bottom-fixed*
MW capacity (3 year average)



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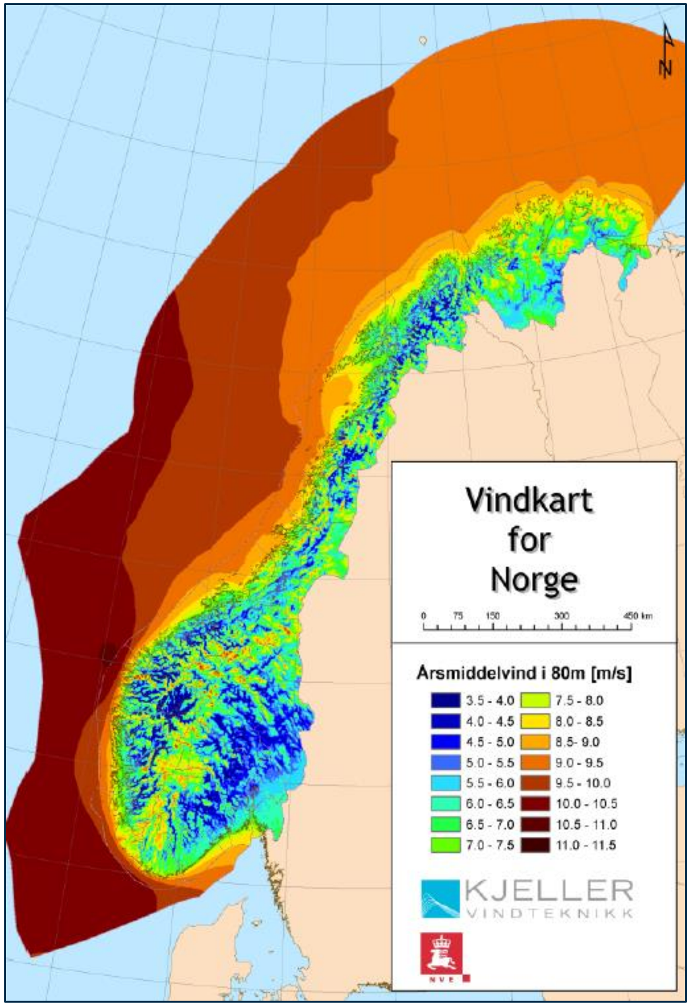
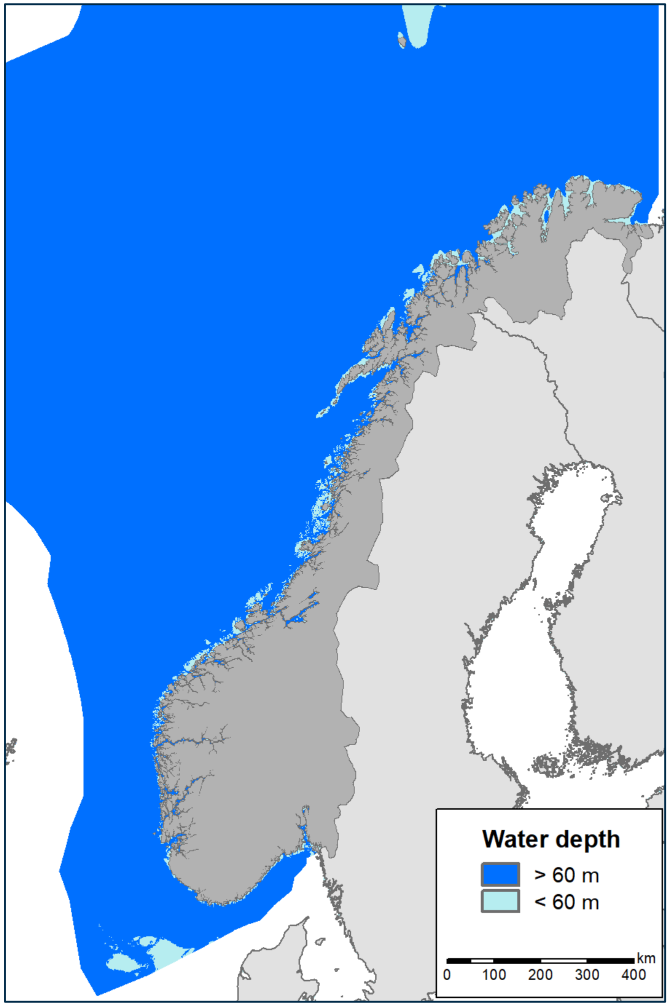
Source: IEA 2019, IRENA 2018, Equinor, BVG Associates 2018, EOLFI 2018, Catapult, Carbonbrief, Rystad Energy research and analysis

2 Fantastic wind resources in Norway and it’s best offshore, but depth calls for floating wind

Wind resources in Norway
Yearly median at 80 m (meter per second)



Water depths on the NCS
Meters



- **Excellent offshore wind resources,** mostly deeper than 60 meters and largely excludes bottom fixed turbines as an offshore wind solution.

Source: NVE; Rystad Energy research and analysis

10 reasons to develop floating offshore wind in Norway

Realize offshore wind resources	Reduce CO_2 emissions	Develop new jobs and industry

5 Norway nears zero emissions in 2050

National emission targets for CO_2 are now echoed by the oil and gas industry, with a 40+% reduction by 2030 and near zero by 2050. Oil and gas extraction accounted for 14 Mt CO_2eq in 2018

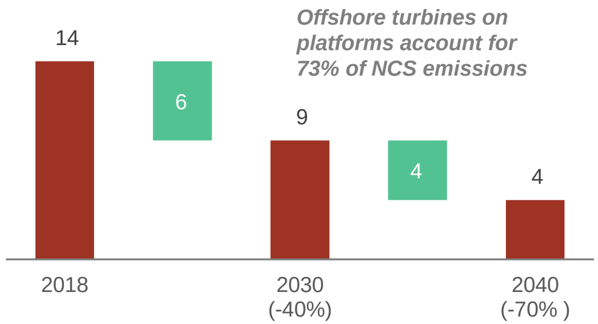
6 Offshore wind to cut O&G emissions

Offshore oil and gas facilities represent large emission point sources located in areas with excellent wind conditions. Offshore wind could thus reduce the need for new onshore power generation associated with large-scale offshore electrification, with limited effect on power prices onshore.

7 Norway can be a global catalyst

Norway can be a global catalyst for commercialization of floating offshore wind, as other countries have been for solar PV and bottom-fixed offshore wind. Accelerated adoption of floating offshore wind globally could yield CO_2 cuts beyond the reduction from single projects.

NCS oil and gas emissions targets
Million tonnes CO_2 eq.



Source: UCube; Statnett – Et elektrisk Norge (April 2019); Menon (Sept 2019); Norsk olje og gass (Jan 2020); Rystad Energy research and analysis

10 reasons to develop floating offshore wind in Norway

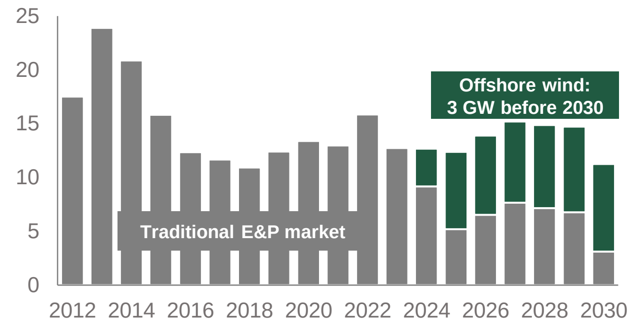
Realize offshore wind resources	Reduce CO_2 emissions	Develop new jobs and industry

8 Good match for Norwegian suppliers
Norwegian suppliers are very well positioned to reap the benefits of industrialization of floating offshore wind. This is already illustrated through awarded contracts on existing small-scale floating wind projects.

9 Oil & gas industry needs to diversify
Domestic construction workload for E&P infrastructure (excl. subsea) set to decline rapidly in the mid-2020s. Offshore floating wind represents a new adjacent growth opportunity, to further develop existing capabilities into new applications.

10 Large export potential if successful
Global market potential for floating wind is estimated at ~2500 billion NOK (2025-2050), of which the Norwegian supplier industry typically could compete for 3-20%. A considerable home market will improve the odds of establishing a new export industry in Norway, as export revenues from oil and gas decline.

Norwegian market for offshore infrastructure fabrication
Billion NOK nominal



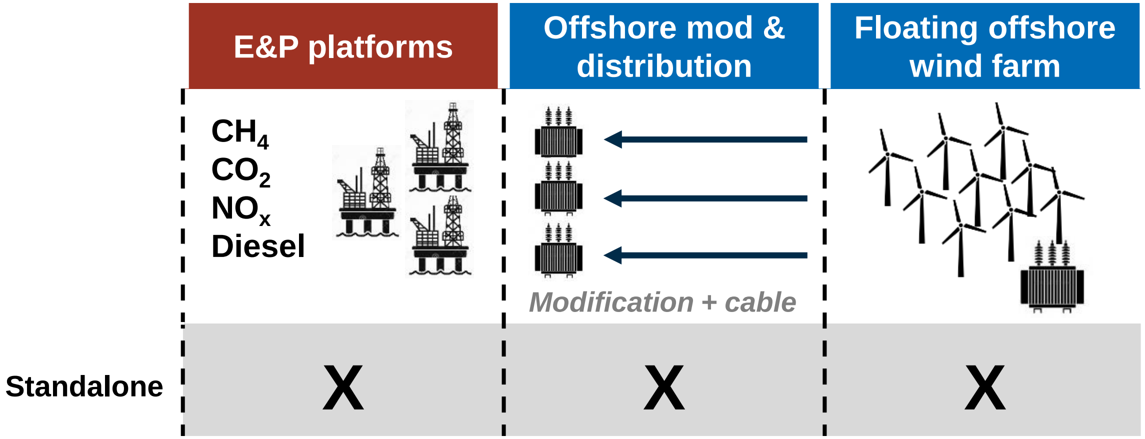
Source: UCube; Statnett – Et elektrisk Norge (April 2019); Menon (Sept 2019); Norsk olje og gass (Jan 2020); Rystad Energy research and analysis

Our focus when analyzing opportunities for floating offshore wind towards oil and gas

Key assumptions and limitations of the report	
Floating offshore wind	• *Floating offshore wind focus, bottom-fixed offshore wind already commercialized.* • *Large scale bottom-fixed offshore wind limited to the Southern North Sea area.*
Large scale farms	• *Cost reductions and industrialization of floating offshore wind requires scale (~500 MW)*
Wind parks sized to match offshore energy demand	• *Energy from wind farm to match offshore energy demand, with zero net draw on onshore electricity production*
Supplier industry invest for scale	• *Cost levels reflects large-scale projects with proven technologies and supplier industry that builds for scale rather than individual projects*
Other factors out of scope	• *Costs and assessment of onshore grid upgrades, also required for power from shore* • *Indirect costs and benefits of platform electrification is not included; impacts on regularity/downtime, future production profiles and remaining lifetime* • *Not considered impacts on fishing, shipping, military activity or other environmental factors* • *CO2 reductions only include reductions in direct offshore emissions (Scope 1)*
External analysis	• *Review at field level and close dialogue with the industry, but still uncertain technical, commercial and legal factors, incl. modification scope, cost of wind farm, fiscal regime etc.*

Concepts to realize offshore wind to E&P:

Standalone concept – Hywind Tampen already demonstrated, is it suitable for large scale?



- **Standalone case: Hywind Tampen analogy, replacement potential is limited by intermittency and stability issues**

Source: Rystad Energy research and analysis

Exchange to shore concept - enables larger wind farms and avoids offshore backup

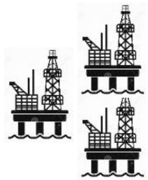
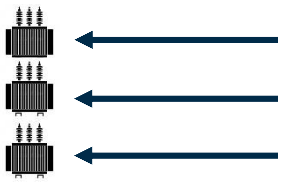
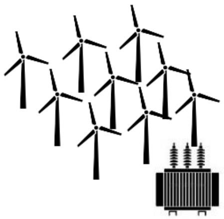
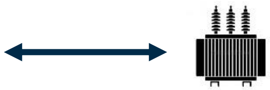
	E&P platforms	Offshore mod & distribution	Floating offshore wind farms	Onshore connection	Onshore grid
	CH_4 CO_2 NO_x Diesel	*Modification + cable*		*Cable + terminal*	*Spot price*
Standalone	X	X	X		
Exchange to shore	X	X	X	X	X

- Standalone case: Hywind Tampen analogy, replacement potential is limited by intermittency and stability issues
- Exchange to shore: Able to electrify larger share of offshore energy demand, as it solved intermittency issue of offshore wind. Wind farms are scaled to meet energy demand of platforms, net self supplied

Source: Rystad Energy research and analysis

Concepts to realize offshore wind to E&P:

Offshore grid concept - utilizes existing or future offshore power grids

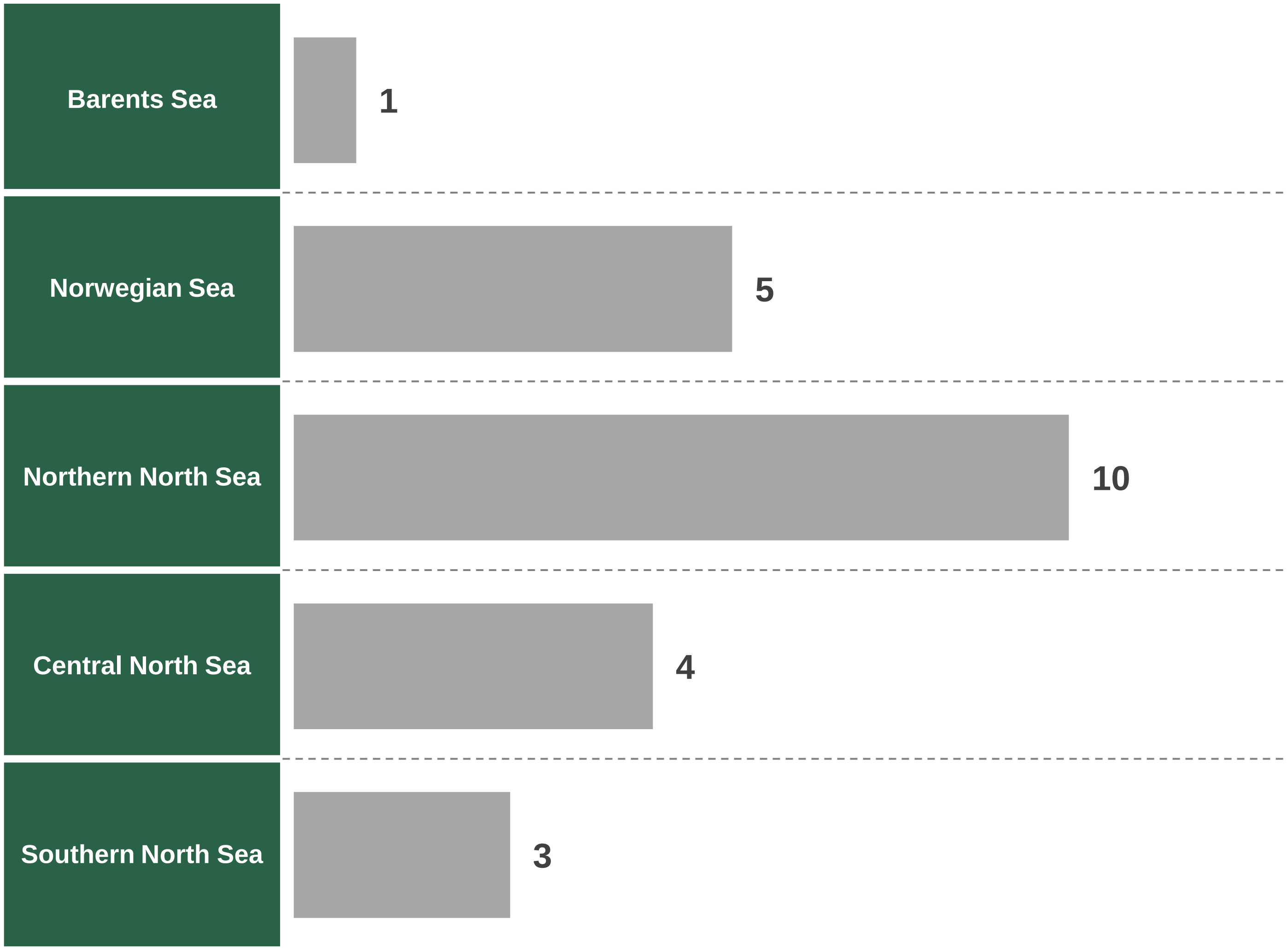
	E&P platforms	Offshore mod & distribution	Floating offshore wind farm	Onshore connection	Onshore grid
	CH_4 CO_2 NO_x Diesel 	 *Modification + cable*		 *Cable + terminal*	 *Spot price*
Standalone	X	X	X		
Exchange to shore	X	X	X	X	X
Offshore grid	X *Spot price*	*In place*	X	*In place*	X

- Standalone case: Hywind Tampen analogy, replacement potential is limited by intermittency and stability issues
- Exchange to shore: Able to electrify larger share of offshore energy demand, as it solved intermittency issue of offshore wind
- **Offshore grid: Deliver power to E&P platforms through existing offshore grid**
- **All three concepts are assumed feasible within the current petroleum tax regime, with constraints on ownership and purpose of the wind farm**

Source: Rystad Energy research and analysis

Total of ~23 TWh required for a all electric NCS

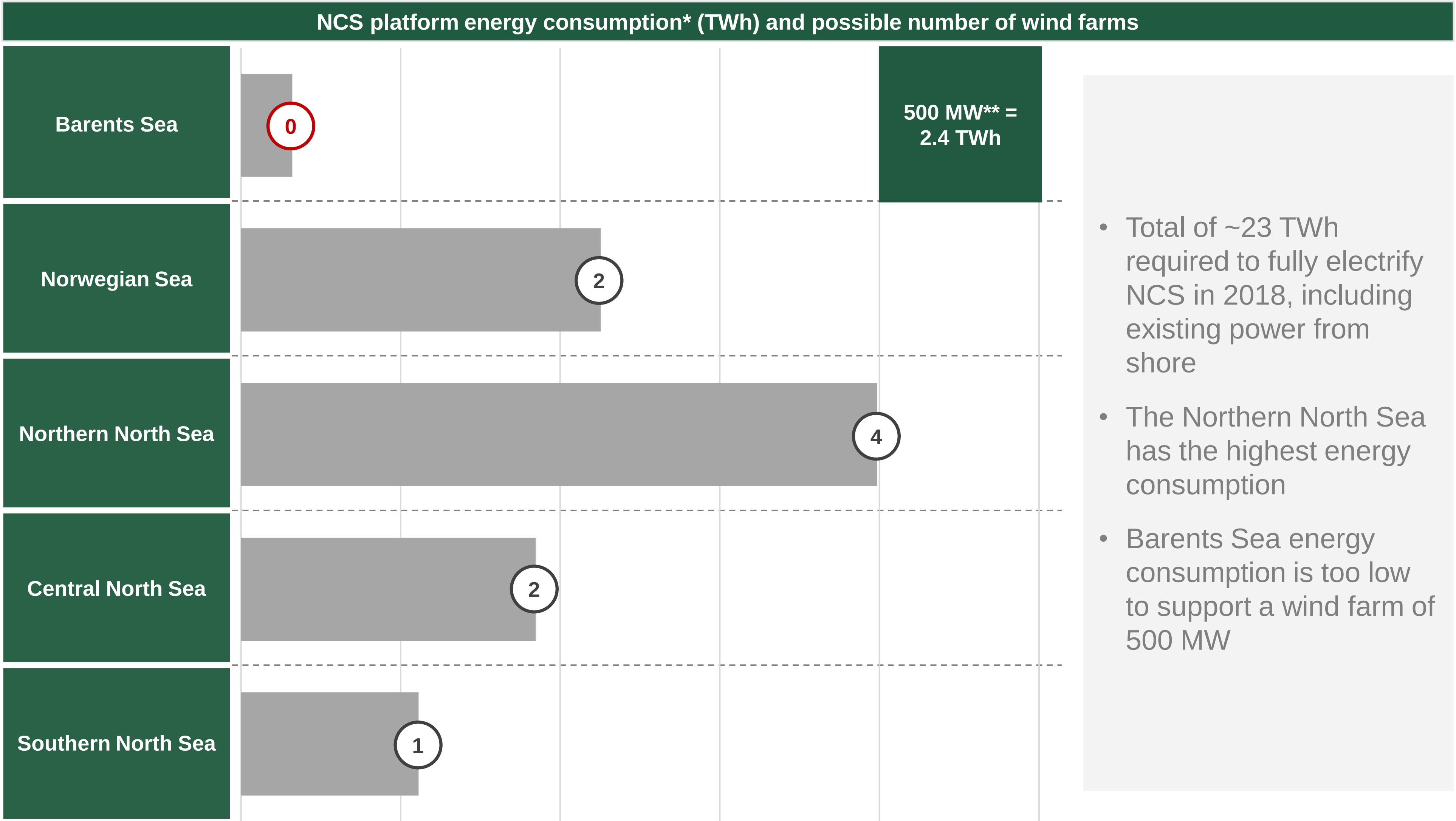
NCS platform energy consumption* (TWh) and possible number of wind farms



- Total of ~23 TWh required to fully electrify NCS in 2018, including existing power from shore
- The Northern North Sea has the highest energy consumption

*Defined as the amount of electric power supply (TWh) needed to replace current energy use on platforms, including WHRUs. Calculations are based on 2018 fuel consumption and 2018 utilization rates
**A capacity factor of 55% is assumed
Source: Rystad Energy research and analysis

NCS facilities could theoretically absorb 9 wind farms to deliver 4.5 GW of capacity



- Total of ~23 TWh required to fully electrify NCS in 2018, including existing power from shore
- The Northern North Sea has the highest energy consumption
- Barents Sea energy consumption is too low to support a wind farm of 500 MW

*Defined as the amount of electric power supply (TWh) needed to replace current energy use on platforms, including WHRUs. Calculations are based on 2018 fuel consumption and 2018 utilization rates
**A capacity factor of 55% is assumed
Source: Rystad Energy research and analysis

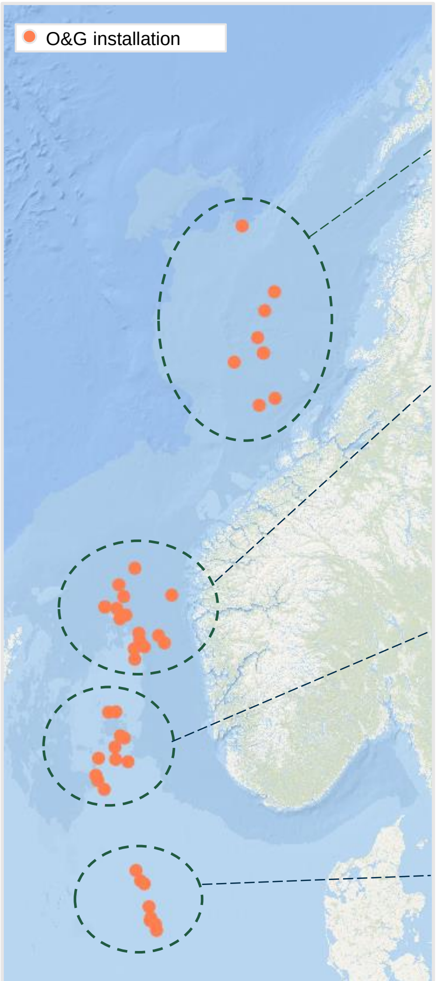
Numerous complicating factors affect the attractiveness of floating wind for E&P

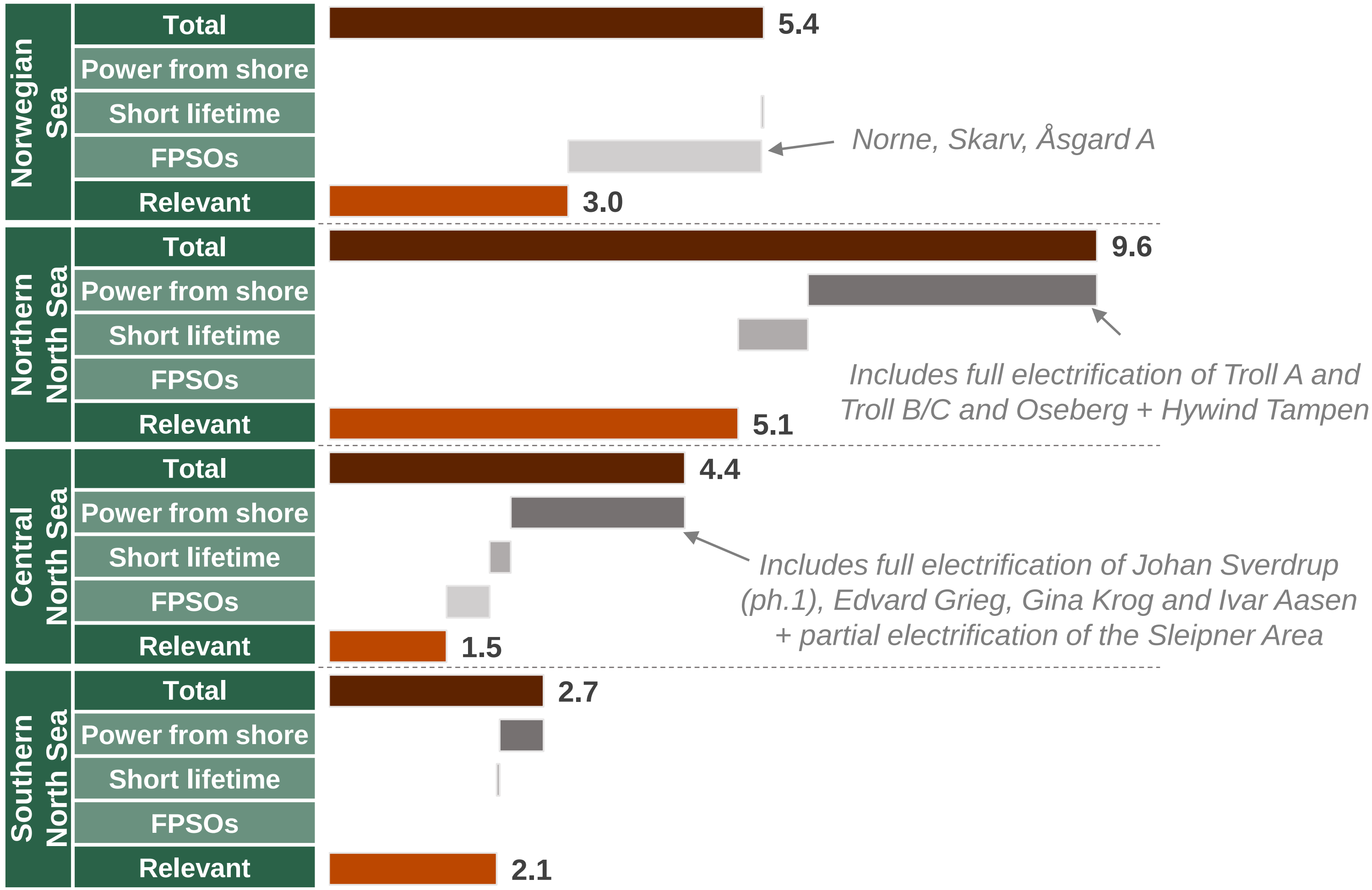
Complicating factors	Rationale	NCS energy demand (2018)
Energy costs	**Platform specific fuel and emissions costs**	***48%*** *with energy cost above 75 øre/KWh*
Electrification with power from shore	**Low energy cost for platforms with power from shore**	***30%*** *already or planned to be electrified from shore*
Lifetime	**Remaining lifetime of platforms is key for economics**	***7%*** *from facilities with less than 10 years remaining life*
FPSO	**Cost efficient electrification of FPSOs not matured**	***13%*** *of energy demand from FPSOs*
Utilization of installed capacity	**High utilization beneficial as modification and distribution costs scale with capacity**	***25%*** *from facilities with <50% utilization of installed capacity*
Full vs partial electrification	**Full electrification more costly than partial electrification, depending on layout and operations**	***33%*** *from equipment directly driven by turbines (non-electric)*
Hz	**Combining platforms with same frequency reduce need for frequency converters**	*~* ***50/50*** *split between 50Hz and 60Hz frequency on platforms*
Distances	**Power transmission and distribution costs scale with distance to shore and distance between platforms**	***21%*** *located more than 200 km from shore*

*Defined as the amount of electric power supply (TWh) needed to replace current energy use on platforms, including WHRUs
**Includes all energy consumption on already and planned electrified platforms, both fully and partially. ***Goliat included in non-FPSOs due to no turret. ****Remaining lifetime as reported by the operators
Source: Rystad Energy research and analysis

Complicating factors reduce the relevant energy consumption by ~50%, down to ~12 TWh

NCS* installations' energy consumption by group and area (TWh)**

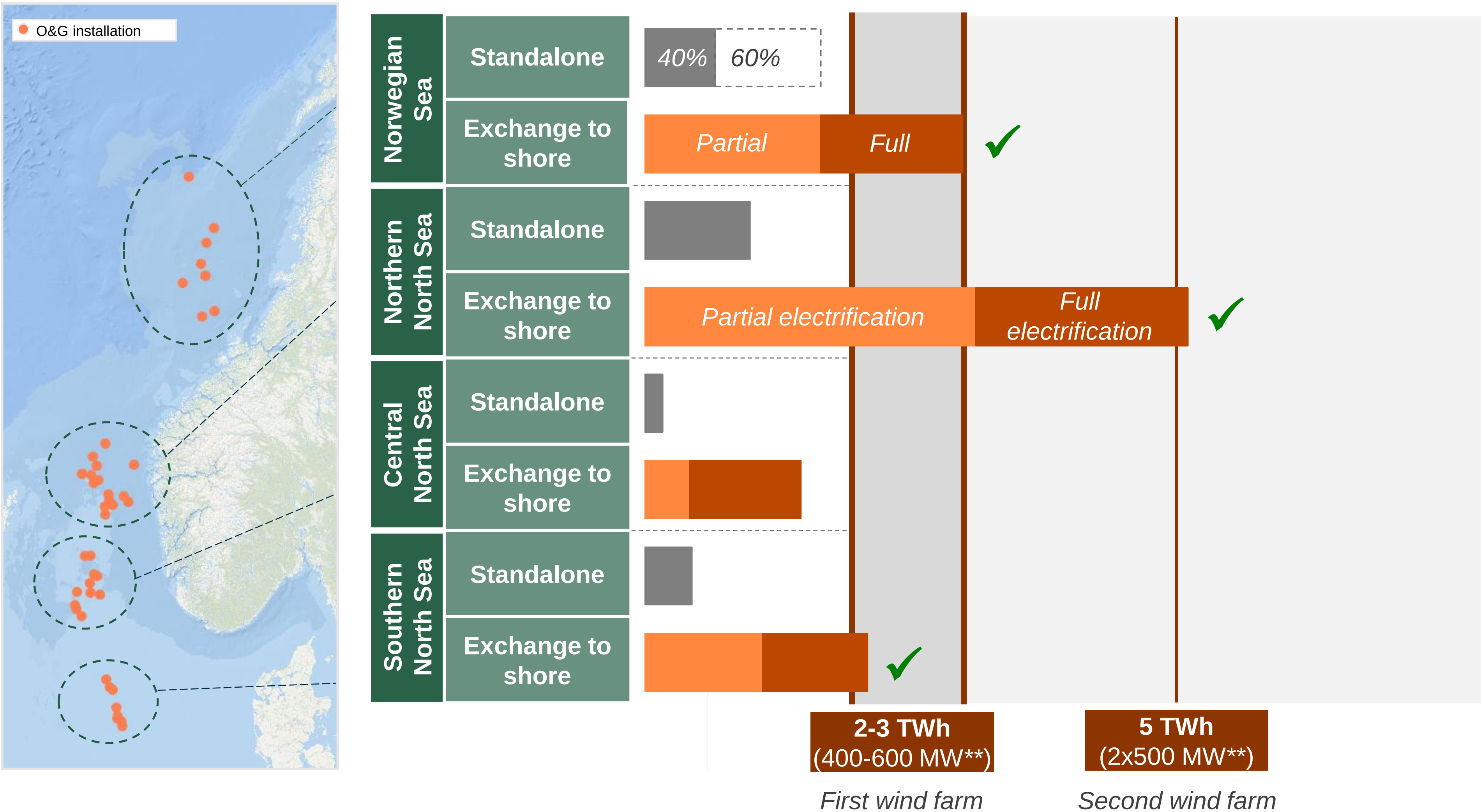




*Excl. Barents Sea **Defined as the amount of electric power supply (TWh) needed to replace current energy use on platforms, including WHRUs. Calculations are based on 2018 fuel consumption and 2018 utilization rates
Source: Rystad Energy research and analysis

Exchange to shore required for sufficient offshore energy demand, no large-scale standalone

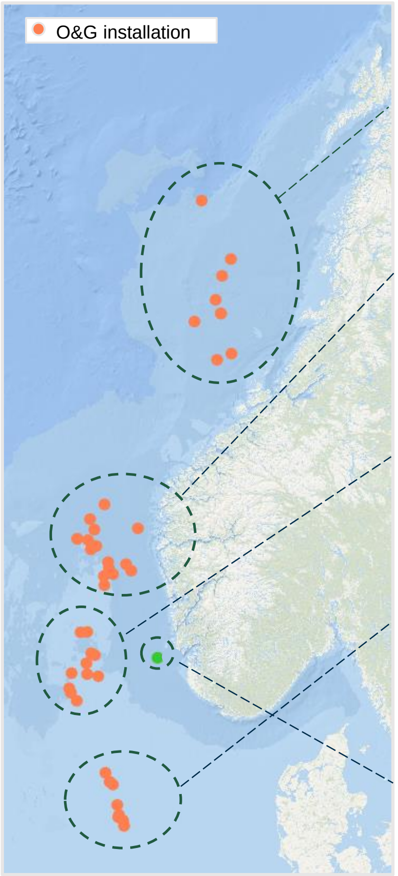
NCS* installations' energy consumption** by group and area (TWh)



*Excl. Barents Sea **Defined as the amount of electric power supply (TWh) needed to replace current energy use on platforms, including WHRUs.
Source: Rystad Energy research and analysis

Four E&P cases identified – three with exchange to shore, and one to existing offshore grid

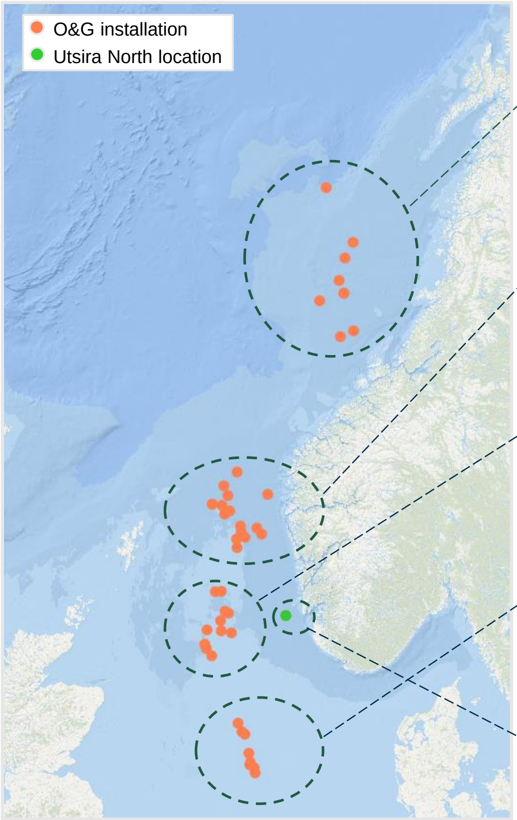
Case selection overview



	Standalone	Partial electrification with exchange	Full electrification with exchange	Offshore grid	Onshore grid
Norwegian Sea			✓ *All candidates needed*		
Northern North Sea		✓ *Optimal case a combination of partial and full electrification*	✓		
Central North Sea				✓ *Utsira High grid*	
Southern North Sea			✓ *All candidates needed*		
Utsira North (Reference case)					✓ *Utsira North*

Source: Rystad Energy research and analysis

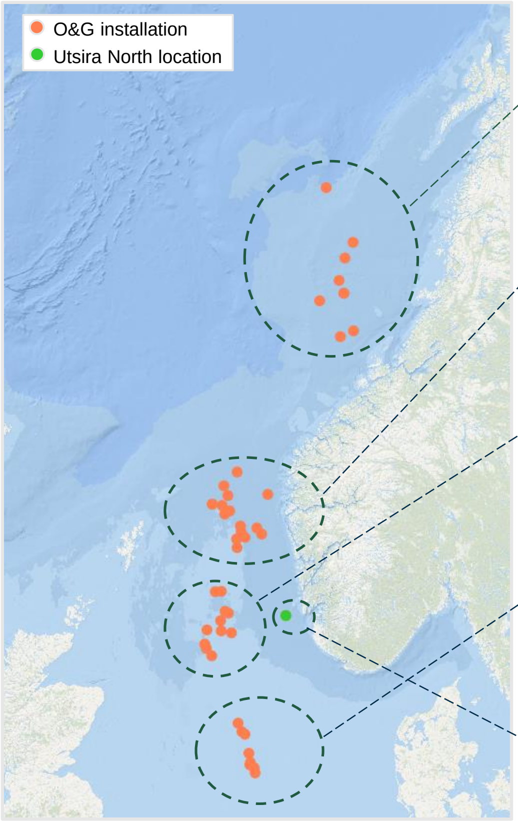
Key indicators for attractiveness of identified E&P cases



Area	Power price at platform*	Modification scope	Remaining life of platforms	Distance to shore	Tax regime
Norwegian Sea	73 øre/kWh	Full	Medium	Medium	Petroleum
Northern North Sea	110 øre/kWh	Partial and full	Medium	Low	Petroleum
Central North Sea	*Spot price*	None	Very long	Medium	Petroleum
Southern North Sea	75 øre/kWh	Full	Very long	High	Petroleum
Utsira North (reference case)	*Spot price*	None	Very long	Very low	Onshore

Assumptions: Discount rate: 8% nominal; Tax system: Norwegian petroleum fiscal regime (for Utsira North: Norwegian onshore fiscal regime); General inflation 2%
*Power price willing to pay at platform, assuming that platforms pay for modifications, but not transmission/distribution cost of bringing power to the platform.
Source: Rystad Energy research and analysis

Northern North Sea commercial with LCOE of floating offshore wind of ~1 NOK/kWh

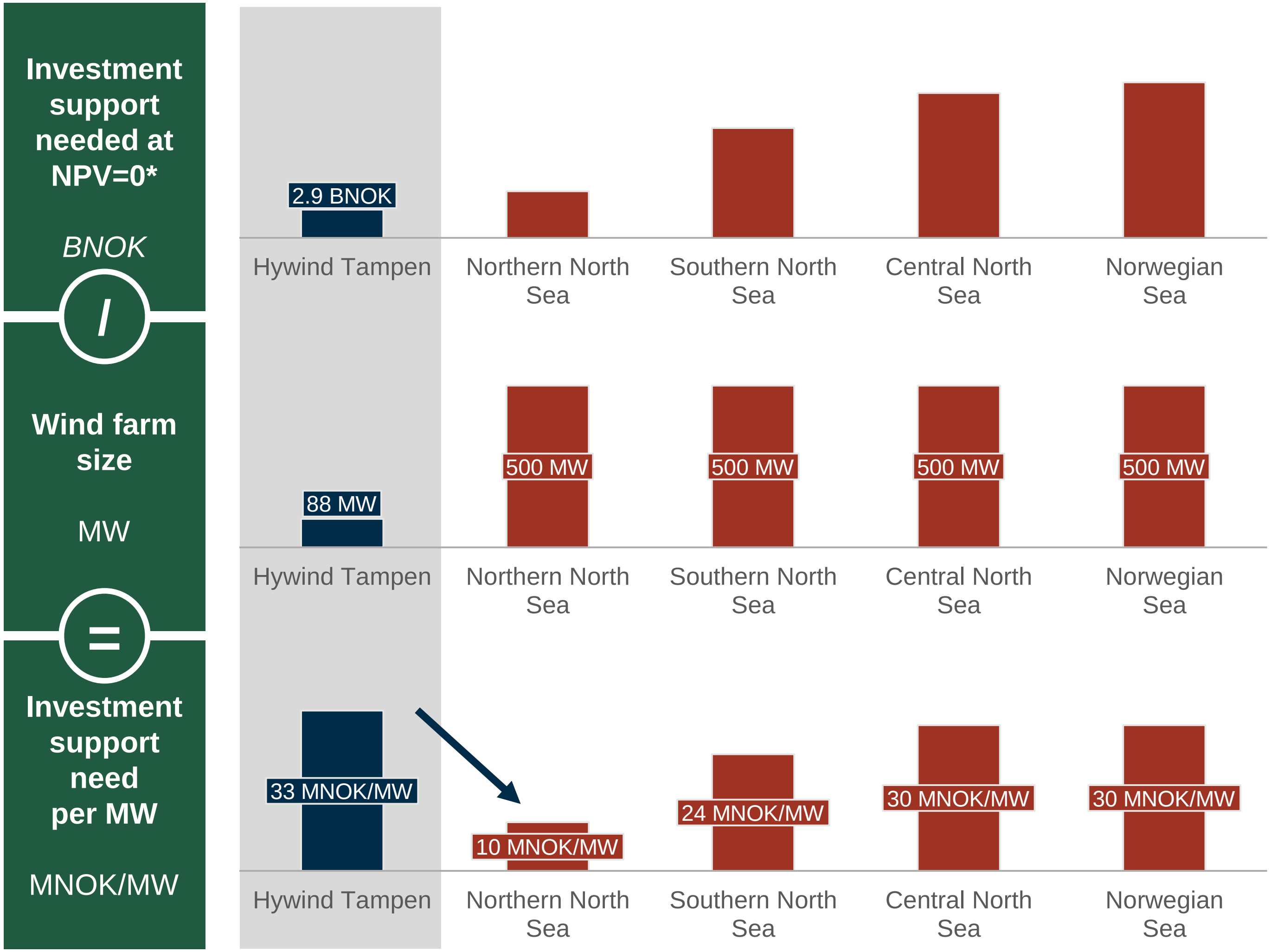


Area	Concept	NPV (8%)	IRR (nominal)	LCOE for NPV=0*
Norwegian Sea	*E&P exchange to shore*	**- 6.5** MNOK / MWwind	**3** %	**59** NOK-øre / kWh
Northern North Sea	*E&P exchange to shore*	**- 2** MNOK / MWwind	**6** %	**95** NOK-øre / kWh
Central North Sea	*E&P existing offshore grid*	**- 6.5** MNOK / MWwind	**1** %	**48** NOK-øre / kWh
Southern North Sea	*E&P exchange to shore*	**- 5** MNOK / MWwind	**4** %	**71** NOK-øre / kWh
Utsira North	*Deliver to Norway onshore grid*	**- 24** MNOK / MWwind	**NA** %	**47** NOK-øre / kWh

Assumptions: Discount rate: 8% nominal; Tax system: Norwegian petroleum fiscal regime (for Utsira North: Norwegian onshore fiscal regime);; General inflation 2%,* The LCOE (pre-tax) for a wind farm needed to make the case commercial. Higher LCOE entails that lower cost cuts are required to make case commercial.
Source: Rystad Energy research and analysis

Less support is required following the initial development of Hywind Tampen

Required investment support per MW in the different area cases

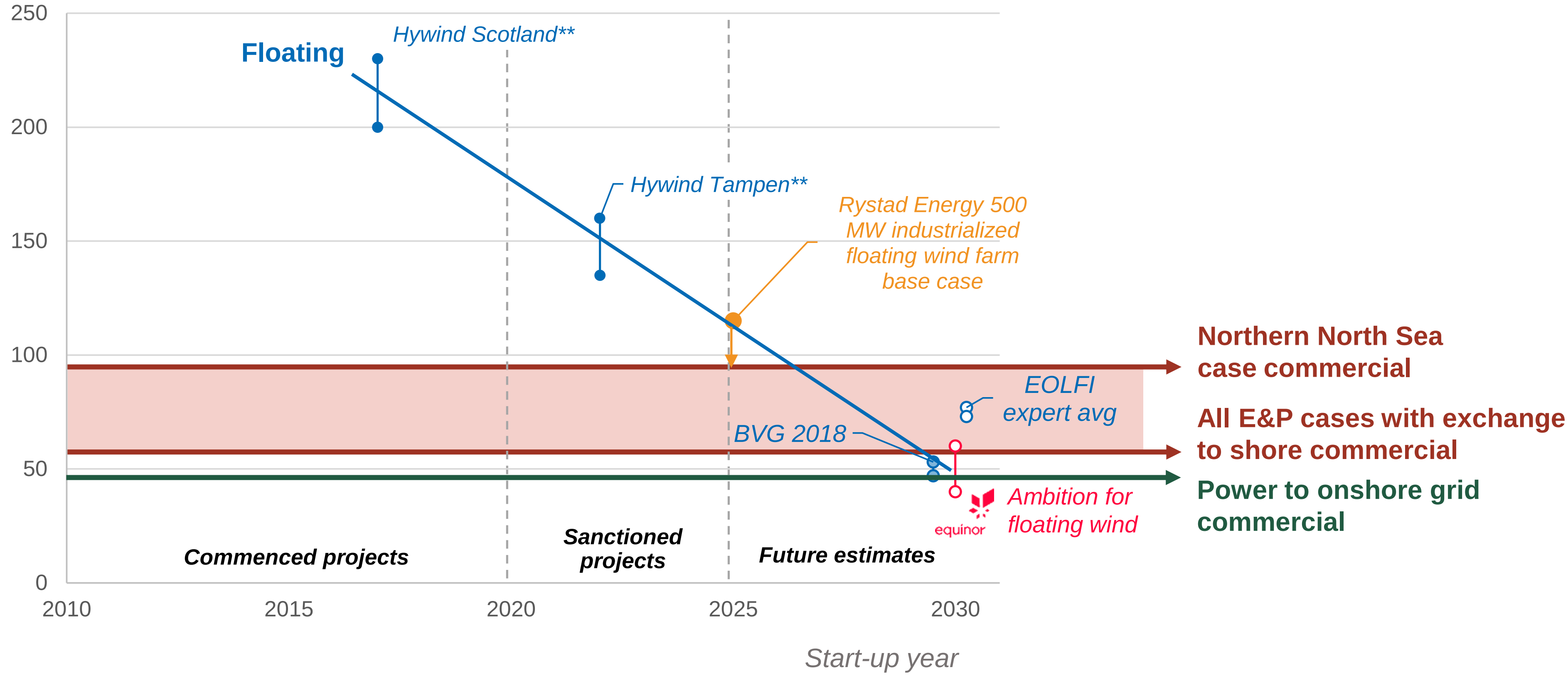


- Different measures to make projects commercial, here indicated with investment support
- Required investment support per MW for NPV=0 of Northern North Sea is ~1/3 of the levels for Hywind Tampen
- The required investment support for the cases range from 5 to 15 BNOK for 500 MW offshore wind farms, based on LCOE of ~115 EUR/MWh in 2025. Lower future LCOE to improve business cases.

*Investment support needed with base case assumptions. The share of investments covered will not get tax return. Hywind Tampen has not stated that their application for ENOVA grant was NPV=0
Source: ENOVA; Hywind Tampen PUD del II; Rystad Energy research and analysis

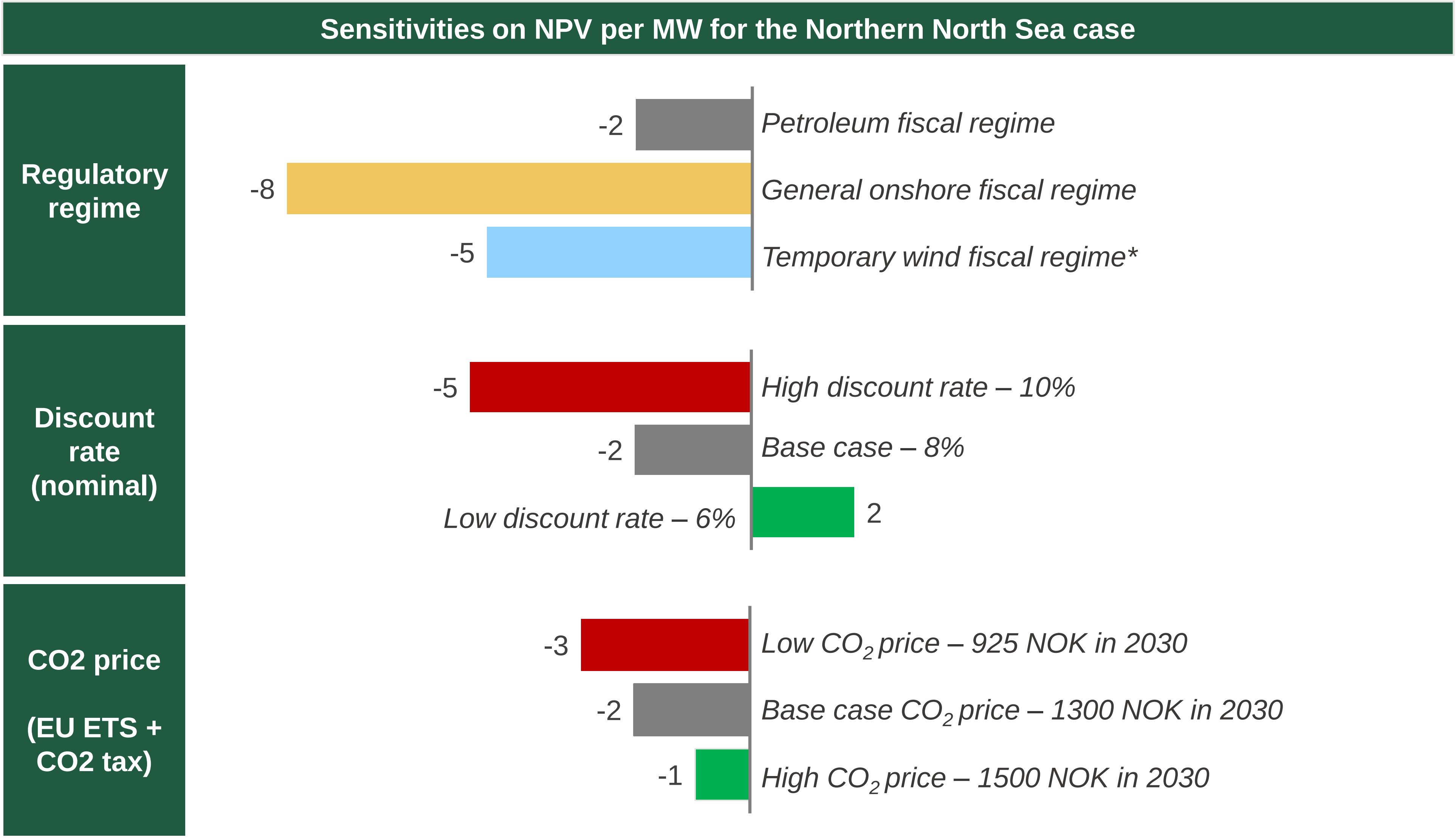
Improved attractiveness of E&P opportunities as costs fall – participate or wait?

Cost curve for floating offshore wind farms* from 2010 to 2030
Levelized cost of energy (LCOE) by start-up year (EUR/MWh)



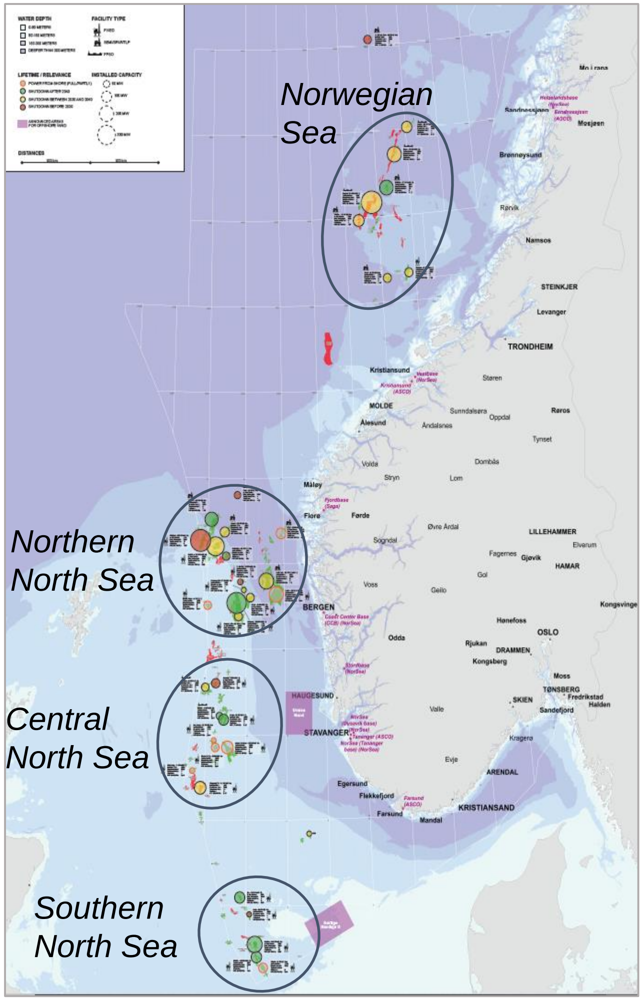
*Data points from stated LCOE with transmission, strike prices or calculated based on 2024 investment cost with a WACC of 8%. Includes transmission to shore.
Source: Equinor, BVG Associates 2018, EOLFI 2018, Rystad Energy research and analysis

Favorable with petroleum fiscal regime and low discount rate, due to large upfront capex



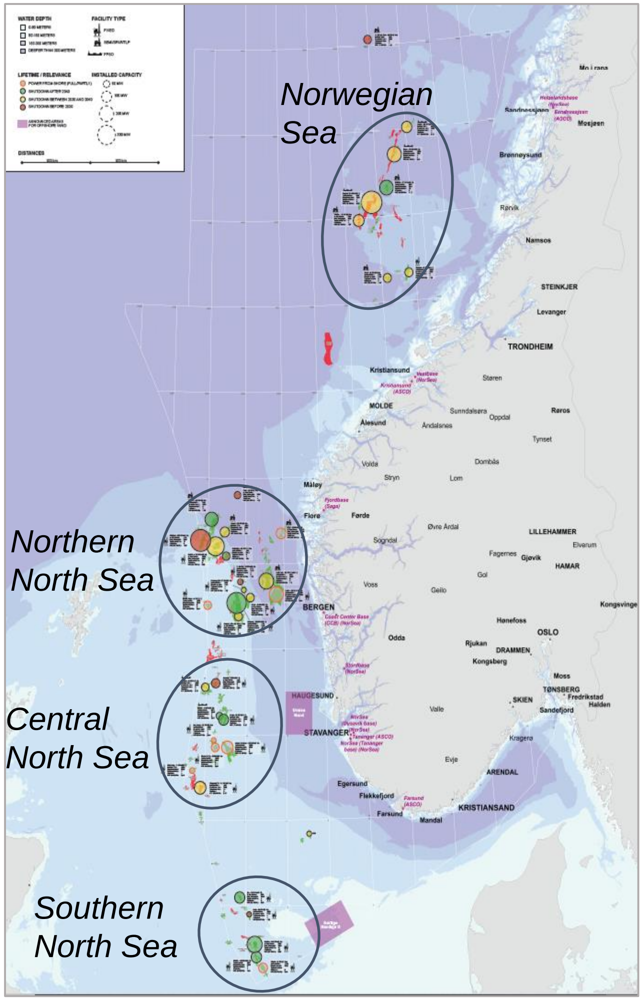
Nominal discount rate with 2% inflation, CO2 price sum of EU ETS and CO2 tax, around 750 NOK/tonne in 2019
*The wind temporary fiscal regime has five years' linear depreciation, and 22% tax rate as the regular onshore regime. Source: Rystad Energy research and analysis

Yes, offshore platforms are attractive off-takers for first large scale floating wind farm(s)



- Oil and gas facilities are attractive first off-takers from large scale floating offshore wind farm(s):
  - Realize offshore wind resources – avoid power from shore
  - Reduce CO2 emission in Norway and aboard
  - Develop new industry, jobs and future export potential
- Combining oil and gas with floating offshore wind is limited to a few large scale wind farms, of which the Northern North Sea area is most attractive.
- Standalone concepts like Hywind Tampen is not suitable for large scale wind farms. Large scale wind farms will require exchange to shore to ensure stable power supply.

…but both public and private stakeholders need to seek solutions and accept inherent risks



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…. realizing this potential will require further efforts:

- Develop efficient and feasible business models across broad set of stakeholders and licensees – open up for external capital?
- How to "close the gap" to make projects commercial viable, realizing positive externalities not valued by individual projects?

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OSLO, 10.03.2020